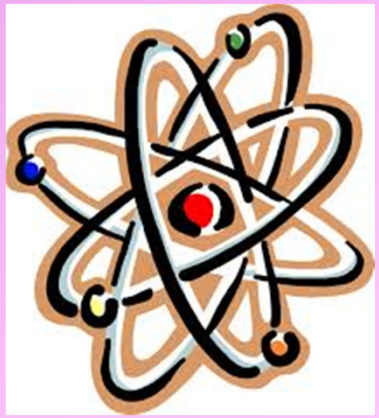
CHEMISTRY OF LIFE

Chapter 2

Ch 2.1: The Nature of Matter

- ***Atom*** =
  - The basic unit of matter
  - Made up of 3 subatomic particles



1. ***Neutrons*** =
   - Neutral (no charge)
   - Found in nucleus
   - Contribute to mass of atom

2. ***Protons*** =
   - –Positive charge
   - –Found in nucleus
   - –Contribute to mass of atom

3. ***Electrons*** =
   - –Negative charge
   - –Orbit the nucleus
   - –Have almost no mass

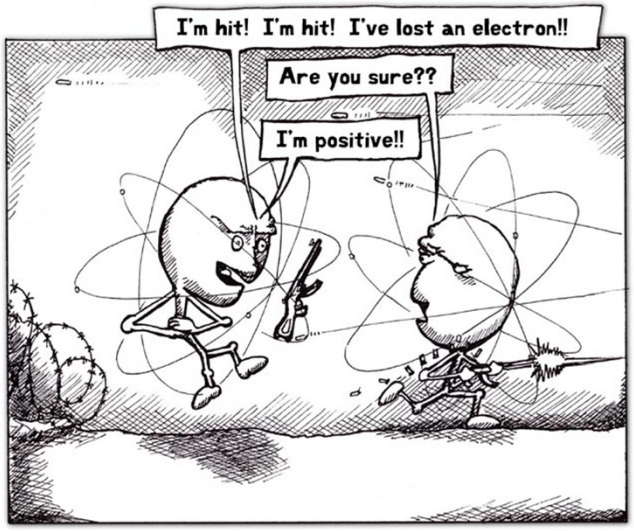
– A neutral atom has the same number of electrons and protons

- ***Element*** =
  - Pure substance that consists entirely of *one type of atom*
  - Each has a unique ***atomic number*** =
    - Number of protons in nucleus of an element
  - Ex: C, O_2, H_2, Na, Cl

- ***Isotope*** =
  - Atoms of the same element that differ in the number of *neutrons*

- ***Molecule*** =
  - 2 or more atoms of an element chemically joined together
  - Ex: O_2, H_2, N_2, H_2O
- ***Compound*** =
  - Pure substance formed by the chemical combination of *2 or more different elements* in definite proportions
  - Ex: NaCl, H_2O
  - Physical and chemical properties of compounds are very DIFFERENT from those of their separate elements

- Chemical Bonds
  - ***Covalent bonds*** =
    - Electrons are shared between atoms
  - ***Ionic bonds*** =
    - Electrons are transferred from one atom to another
    - ***Ions*** =
      - Positively or negatively charged atoms
      - Formed from gain or loss of electrons



Another casualty in the War of the Atoms

Inorganic =

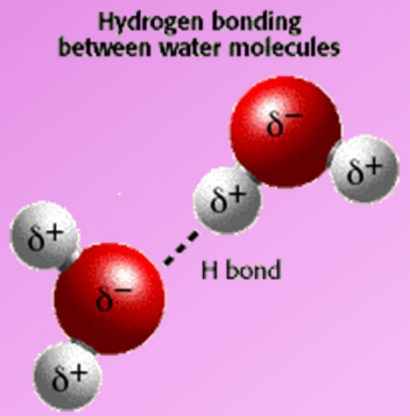
- Molecules that do NOT contain carbon chains
- Examples:
  - Oxygen
  - Carbon Dioxide
  - Water

Organic =

- Molecules that DO contain carbon chains
- Examples:
  - Carbohydrates
  - Lipids
  - Proteins
  - Nucleic Acids
  - ATP

Ch 2.2: Properties of Water

- Polarity
  - Negative pole near oxygen atom
  - Positive pole between hydrogen atoms



- Bonding
  - Polar molecules (like water) can attract each other
  - ***Hydrogen bond*** =
    - Weak attraction between hydrogen atom and another atom
    - Not as strong as covalent or ionic bonds

- Water's special properties
  - Water expands slightly at freezing point (0°C)
    - Ice is less dense than water
    - Ice floats, insulating water below it
  - Water dissolves ionic compounds and other polar molecules

  - ***Cohesion*** =
    - Attraction between molecules of the same substance
    - Water molecules are drawn together
      - Produces surface tension
      - Some insects can "walk on water"

- ***Adhesion*** =
  - Attraction between molecules of different substances
  - Ex: Adhesion between water and straw causes water to rise
    - Called capillary action
    - Draws water out of plant roots into stem/leaves

- High ***Specific Heat Capacity*** =
  - Amount of heat energy required to increase temperature
  - Allows large bodies of water to absorb lots of heat with only small changes in temp

- Water as part of a ***mixture*** =
  - 2 or more elements or compounds that are physically mixed together but NOT chemically combined
  - ***Solution*** =
    - All components are evenly distributed
      - ***Solute*** =
        - » Substance that is dissolved in solution
      - ***Solvent*** =
        - » Dissolving substance in a solution
        - » Water is the “universal solvent”
  - ***Suspension*** =
    - Mixture of water and nondissolved material

- Water can split to form ions

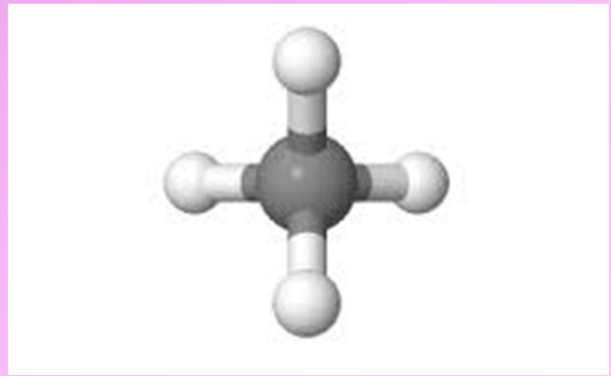
$H_2O \leftrightarrow H^+ + OH^-$

water ↔ hydrogen ion + hydroxide ion

  - pH scale measures concentration of H^+ ions in a solution
  - Pure water has a pH of 7 = neutral
  - ***Acid*** =
    - Forms hydrogen (H^+) ions in solution
    - pH less than 7
  - ***Base*** =
    - Forms hydroxide (OH^-) ions in solution
    - pH greater than 7
  - ***Buffer*** =
    - Prevents sudden changes in pH

Ch 2.3: Carbon Compounds

- Carbon is very versatile because it can form 4 covalent bonds
  - Can bond with many different elements
  - Can bond to other carbons to form long, complex chains
- ***Monomers*** =
  - Smaller units; building blocks
- ***Polymers*** =
  - Composed of many monomers to make macromolecules



- ***Hydrolysis*** =
  - Splits polymers into monomers
  - Bonds are *broken* through the *addition* of water
- ***Dehydration synthesis*** =
  - Joins monomers into polymers
  - *Forms* bonds through the *removal* of water

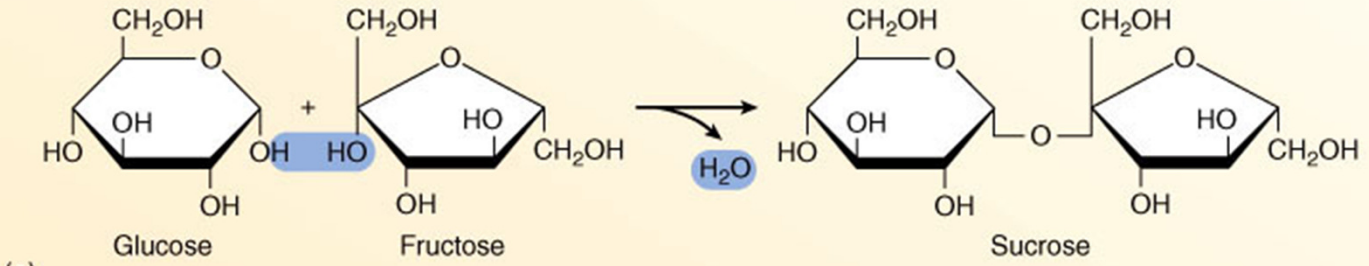
Overview of Macromolecules

Macromolecule	Polymer	Monomer
Carbohydrates	Polysaccharides (starch, cellulose)	Monosaccharides (glucose, fructose)
Lipids	Fats, Oils, Waxes Phospholipids, Steroids	Glycerol and Fatty acids
Nucleic Acids	DNA and RNA	Nucleotides
Proteins	Polypeptides	Amino Acids

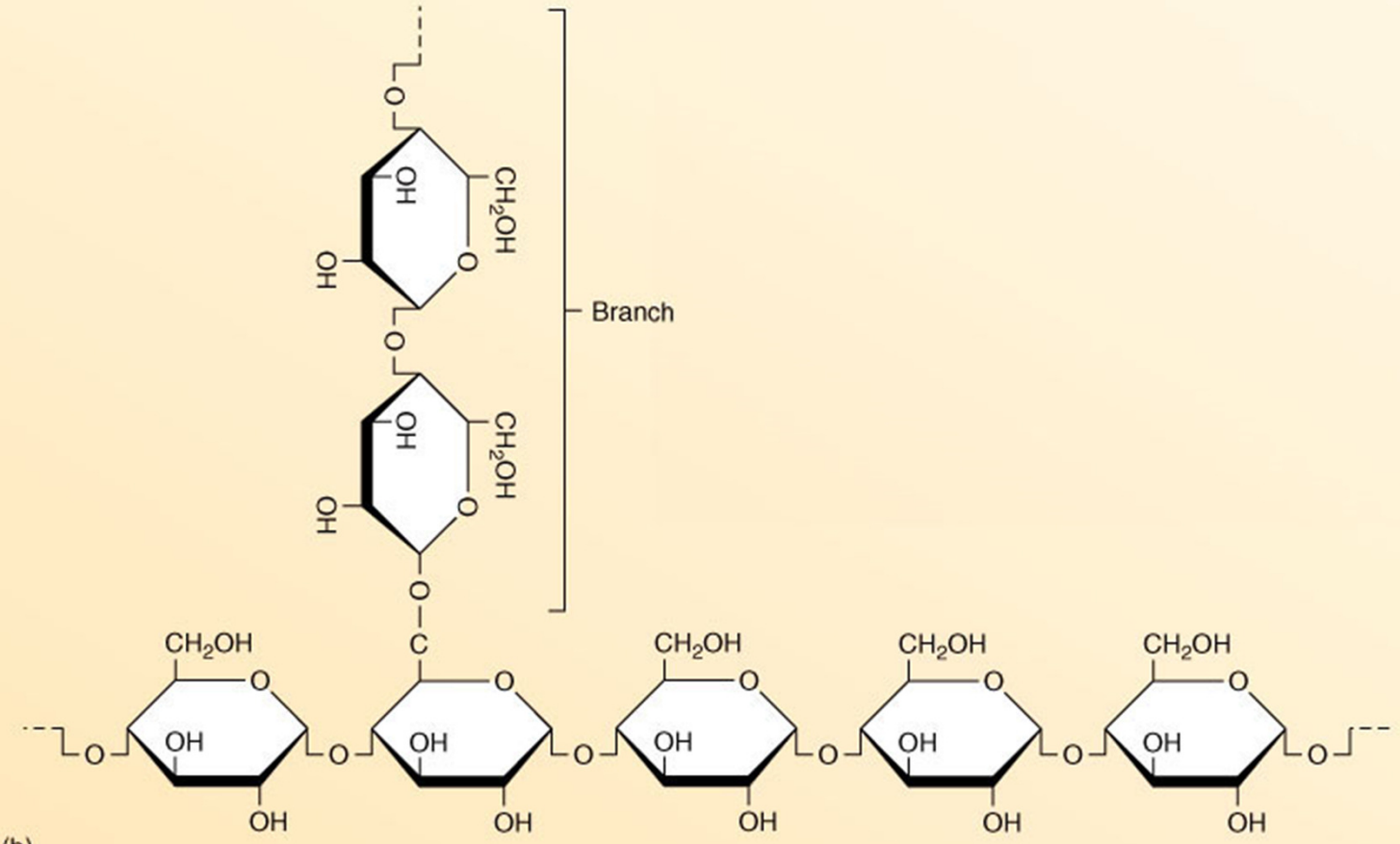
Carbohydrates

- Main source of **energy**
- ***Monosaccharides*** =
  - Simple sugars ($C_6H_{12}O_6$)
  - Examples
    - Glucose
    - Fructose (in fruit)
    - Galactose (in milk)

- ***Disaccharides*** =
  - Formed when two monosaccharides join
    - Example
      - Glucose + fructose = sucrose (table sugar)
- ***Polysaccharides*** =
  - Many monosaccharides bound in long chains
  - Examples
    - Glycogen (animal starch)
    - Plant starch
    - Cellulose
      - Structural component of plant cell walls



(a)

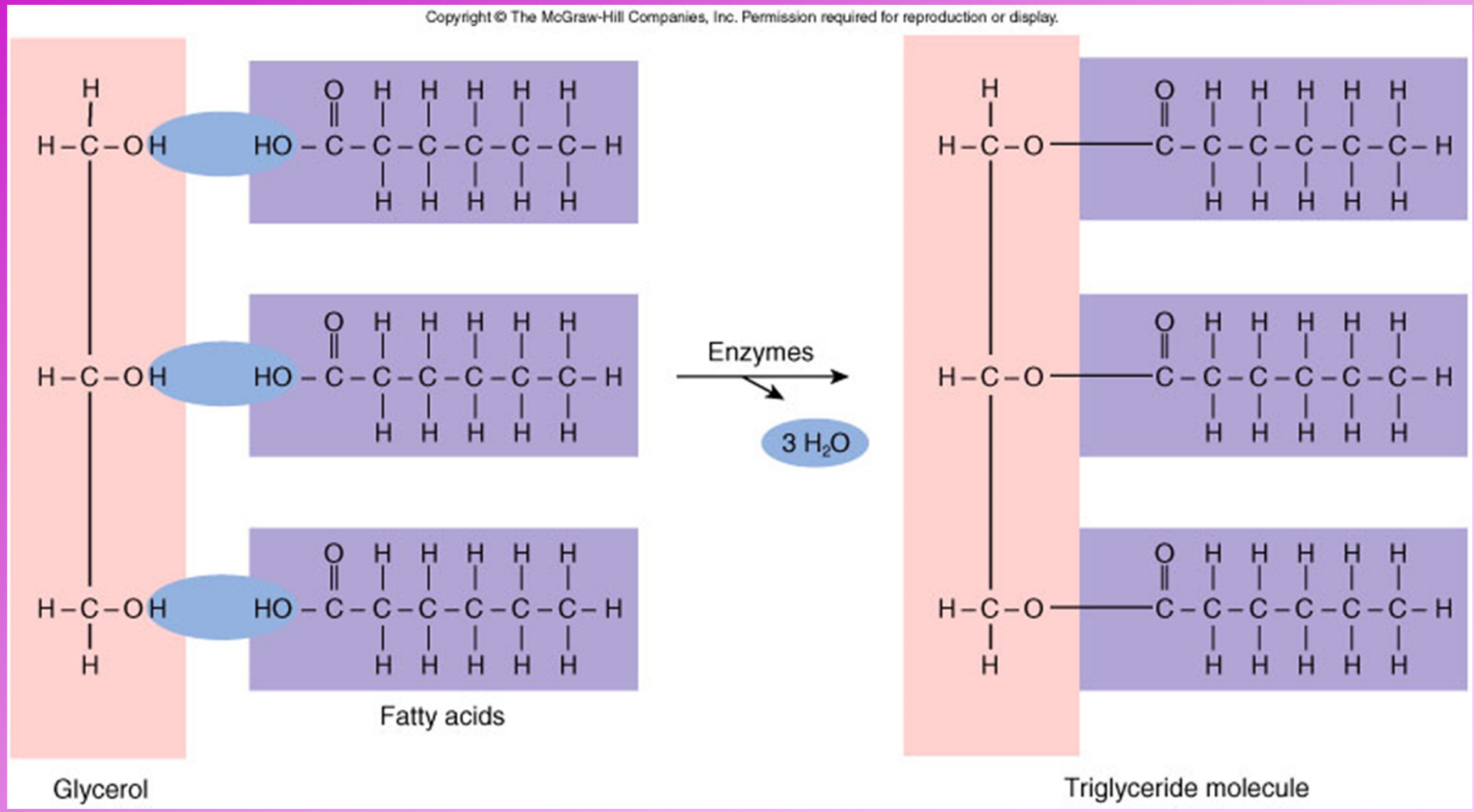


(b)

Lipids

- Not water soluble
- Made up of fatty acids and glycerol
  - Mostly carbon and hydrogen atoms
- Fats, oils, and waxes
  - Store energy
  - Pad and insulate body
  - Form waterproof coverings
- Phospholipids
  - Make up cell membranes
- Steroids
  - Hormones (ex-cholesterol); chemical messengers

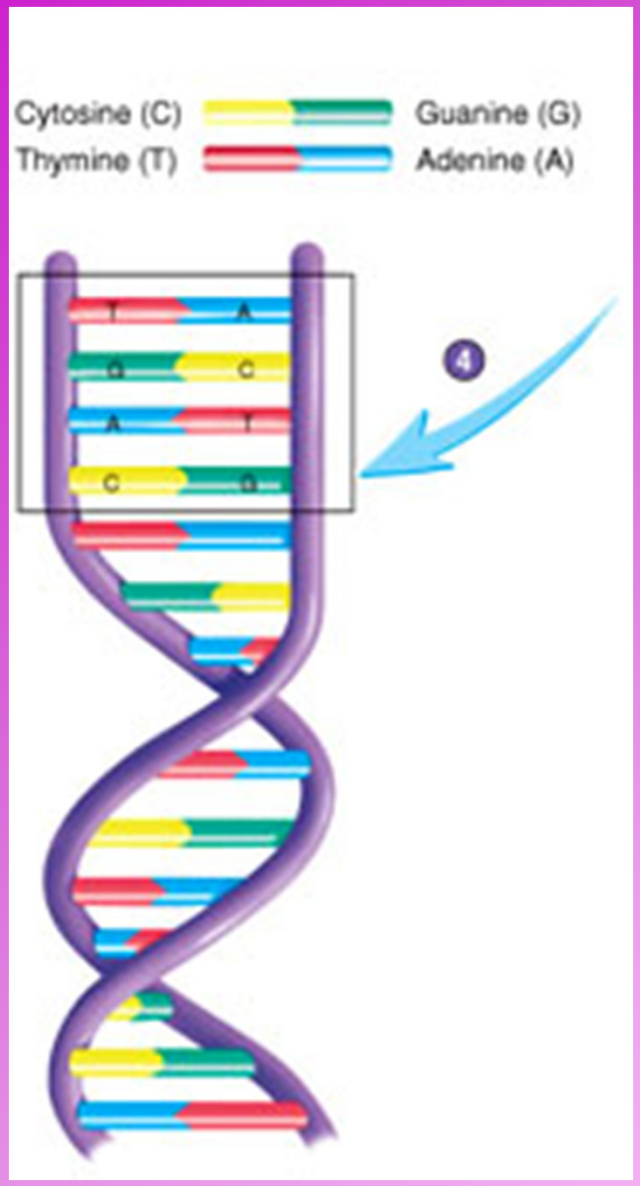
- ***Saturated fats*** =
  - Contains only single covalent bonds between carbon atoms
  - Contribute to development of cardiovascular disease
- ***Unsaturated fats*** =
  - Contain one or more double covalent bonds between carbons
  - Best types of fats in the diet

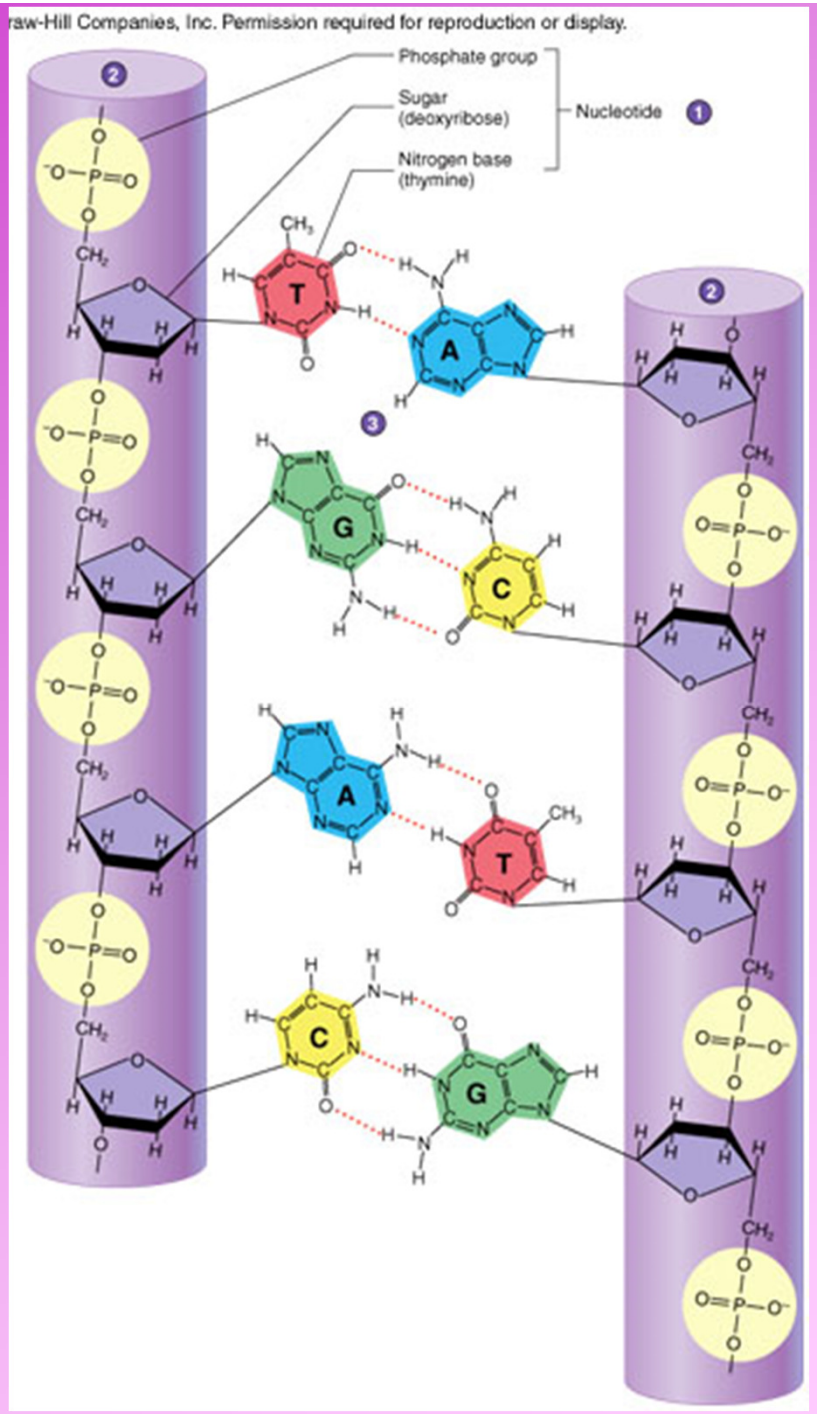


Nucleic Acids: DNA and RNA

- Store and transmit hereditary/genetic information
- Contain carbon, hydrogen, oxygen, nitrogen, phosphorus
- 2 types
  - ***Deoxyribonucleic Acid (DNA)=***
    - Genetic material of cells
  - ***Ribonucleic Acid (RNA)=***
    - Important in protein synthesis

- ***Nucleotides*** =
  - Basic building blocks of nucleic acids
  - Consist of
    - A 5-carbon sugar molecule
    - A phosphate group
    - Nitrogenous bases


Cytosine (C)
Guanine (G)
Thymine (T)
Adenine (A)
T
A
G
C
A
T
C
G
4

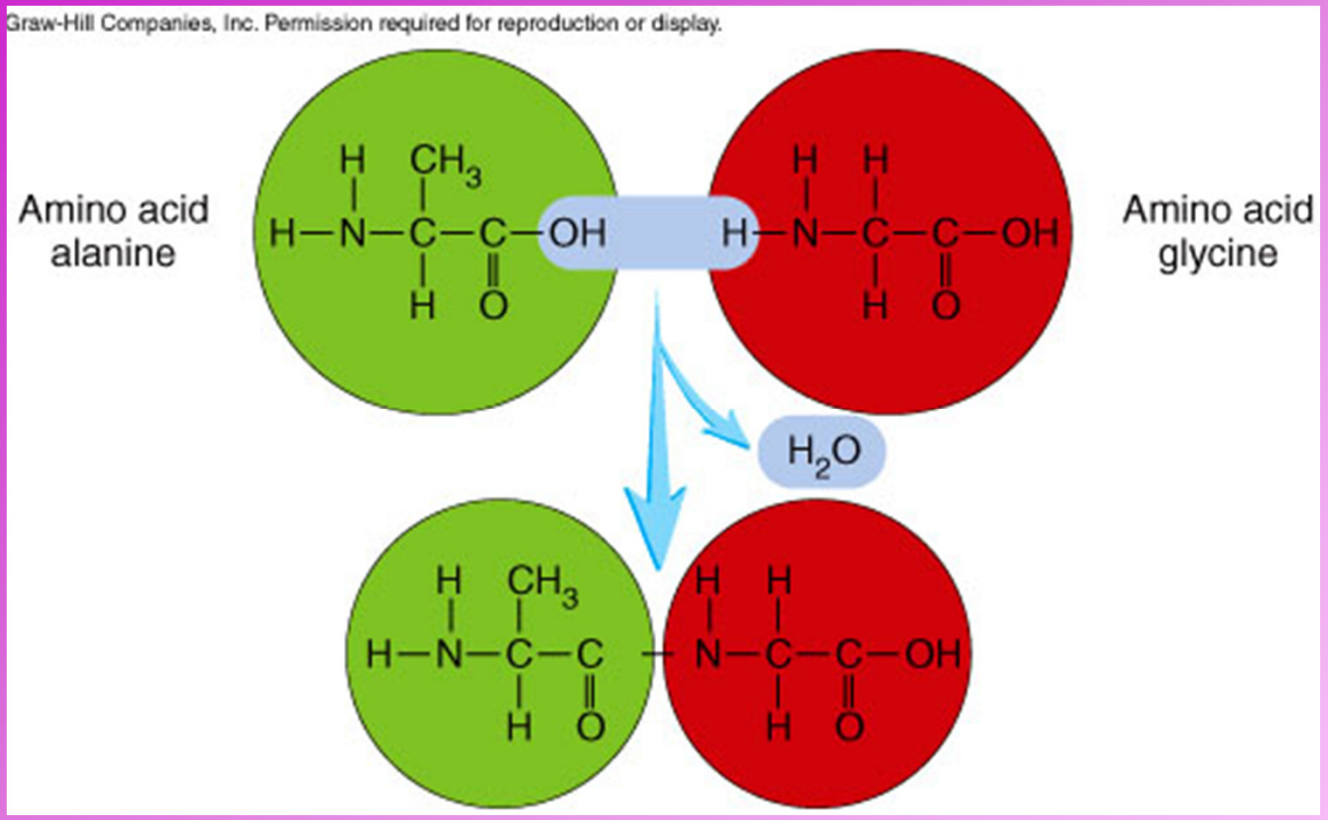

raw-Hill Companies, Inc. Permission required for reproduction or display.
Phosphate group
Sugar
(deoxyribose)
Nitrogen base
(thymine)
Nucleotide
1
2
3
T
A
G
C
A
T
C
G

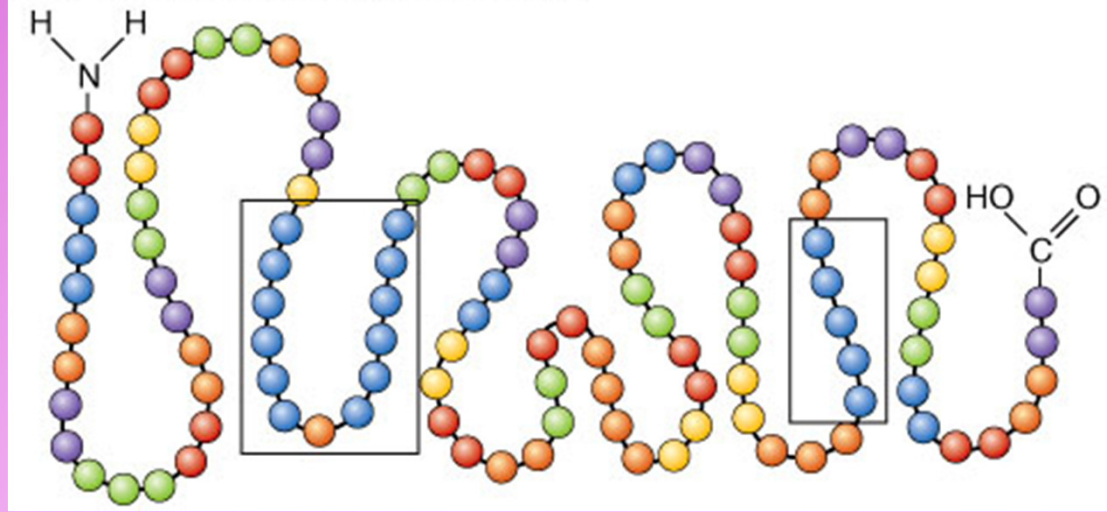
Proteins

- Selectively speed up chemical reactions
  - Enzymes
- Transport substances
  - Hemoglobin: Transports oxygen in blood
- Protect against microorganisms and disease
  - Antibodies: Provide defense
- Coordinate cellular activities
  - Insulin: Hormone that regulates blood sugar
- Movement
  - Actin and myosin: Muscle contraction
- Structural support
  - Collagen and keratin: Framework for skin, hair, etc.

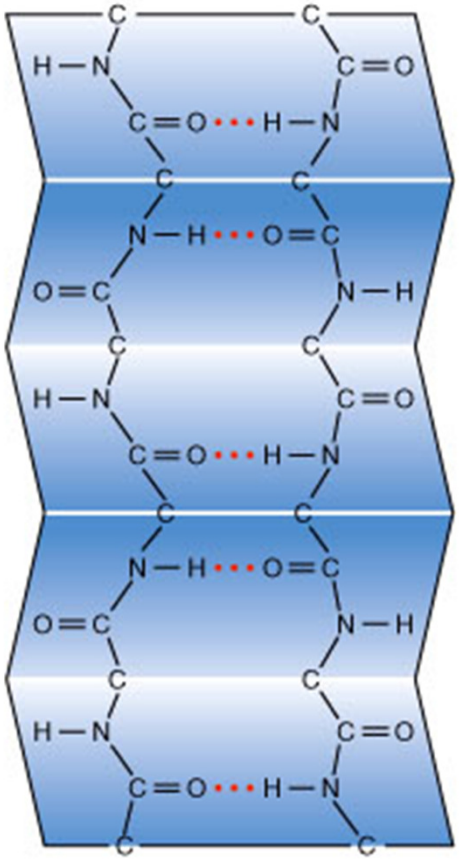
- ***Amino acids*** =
  - Monomers of proteins
  - Contain carbon, hydrogen, oxygen, nitrogen, sulfur
  - Central carbon bonded to
    - Amine group ($-NH_2$)
    - Carboxyl group (-COOH)
    - Hydrogen atom
    - "R" group

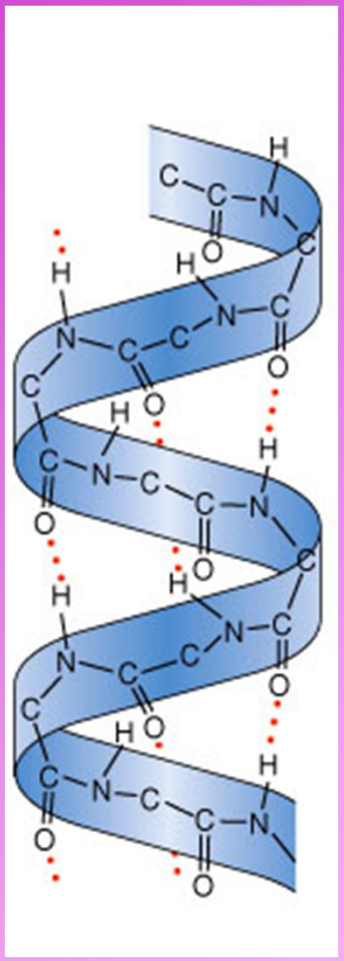
- ***Peptide bonds*** =
  - Covalent bonds that link amino acids together to form a polypeptide

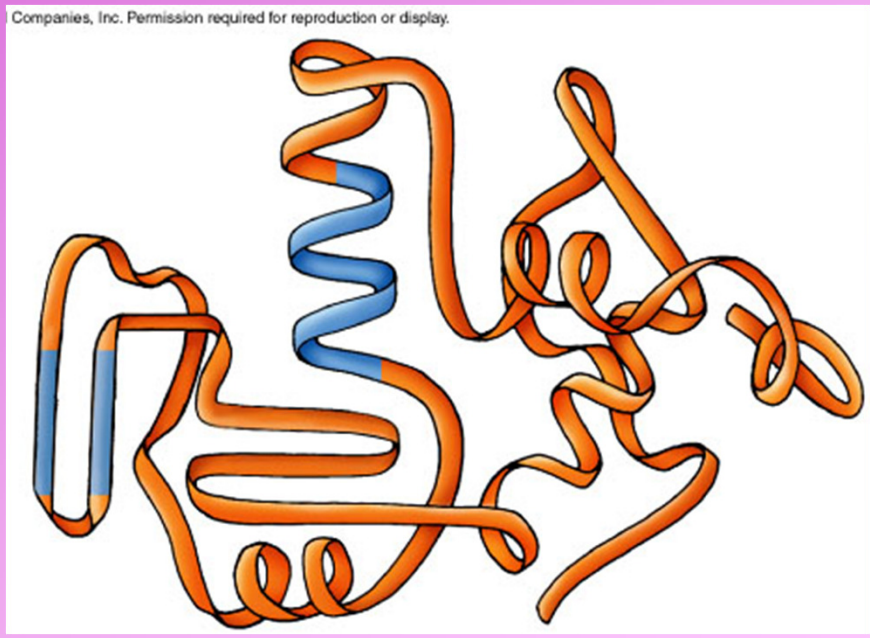




- Protein shape is very important to its function
  1. Primary structure =
     - –Amino acid sequence
  2. Secondary structure =
     - –Folding or coiling of polypeptide chain
  3. Tertiary structure =
     - –3-D arrangement of polypeptide chain
     - –Caused by interactions between amino acids and water
  4. Quaternary structure =
     - –Arrangement of more than one chain







Ch 2.4: Chemical Reactions and Enzymes

- ***Chemical reactions*** =
  - Change one set of chemicals into another
  - ***Reactants*** =
    - Enter chemical reactions
  - ***Products*** =
    - Produced by chemical reactions

- Energy is released or absorbed whenever chemical bonds are formed or broken

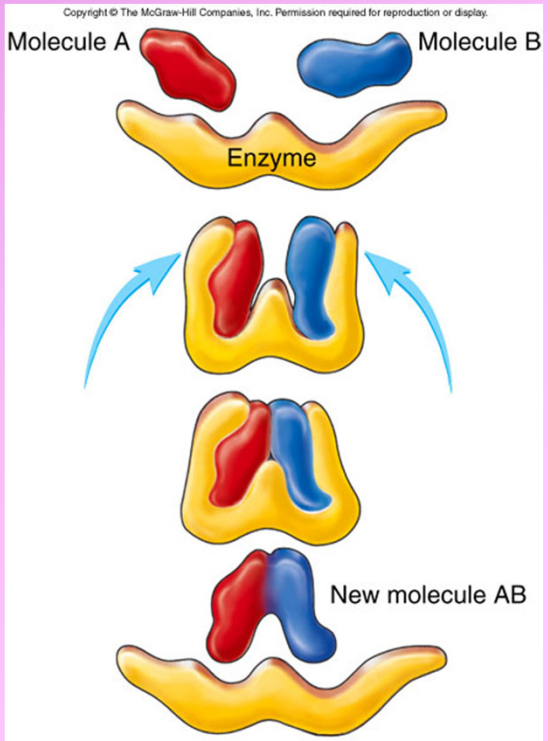
Ch 2.4: Chemical Reactions and Enzymes

- ***Chemical reactions*** =
  - Change one set of chemicals into another
  - ***Reactants*** =
    - Enter chemical reactions
  - ***Products*** =
    - Produced by chemical reactions

- Energy is released or absorbed whenever chemical bonds are formed or broken

- ***Activation energy*** =
  - Energy necessary to start a chemical reaction
- ***Catalyst*** =
  - Substance that speeds up the rate of a chemical reaction
  - Lowers reaction's activation energy
- ***Enzymes*** =
  - Proteins that act as catalysts
  - Speed up chemical reactions in cells
  - Are NOT permanently changed, so they can be reused

- ***Substrates*** =
  - Reactants in an enzyme-catalyzed reaction
  - Bind to active site on the enzyme
- Shape of enzyme is important!
  - Complementary to substrate
  - Certain enzymes only fit certain substrates for certain reactions
    - Lock and key



- As the reaction progresses, what happens to the concentration of each?
  - Reactant/Substrate
    - Concentration decreases
  - Product
    - Concentration increases
  - Enzyme
    - Concentration stays the same

- What affects the rate of a chemical reaction?
  - Enzyme concentration
    - More enzyme = faster rate (if there is enough substrate)
  - Substrate concentration
    - More substrate = faster rate (if there are enough enzymes)
  - Temperature and pH
    - Each enzyme has an optimum temperature and pH at which if functions
    - Increasing temp gradually may increase rxn rate
    - Changing pH or adding too much heat can ***denature*** the protein
      - Change in the **shape** of a protein caused by breaking hydrogen bonds
      - Makes proteins nonfunctional